Shielding a Toroid Amplifier at the Stanford Linear Accelerator Center

The Stanford Linear Accelerator Center (SLAC), which opened in 1966, operates an accelerator two miles long which produces an electron beam with an energy of ten to twenty billion electron volts. Scientists throughout the world use the accelerator as a tool for research in particle physics.

Since the strength of the fields associated with the electron beam may be dangerous to personnel, electronic instrumentation engineers at SLAC wanted to display field strength information on an oscilloscope located some distance from the electron beam. They planned to mount a field strength detecting device inside the pipe through which the electron beam travels. Since the detecting device only produces a small signal, the engineers were going to pass this signal through an amplifier before sending it to the oscilloscope. They intended to mount the amplifier to the detecting device through the wall of the pipe, as shown in Figure 1.

(c) 1967 by the Board of Trustees of the Leland Stanford Junior University.

Prepared in the Design Division of the Department of Mechanical Engineering by Sue Hays under the direction of Professor H. O. Fuchs with financial support from the National Science Foundation.

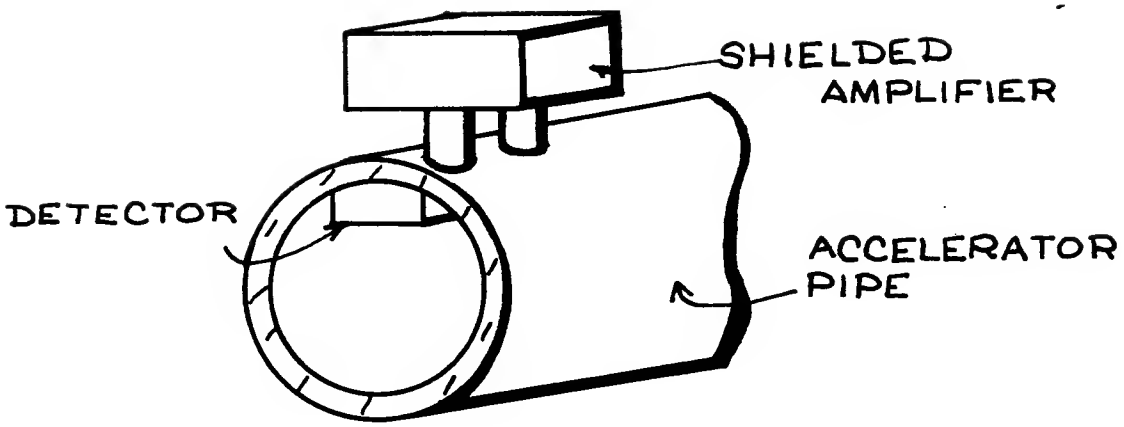


Figure 1

The instrumentation engineers knew that the amplifier would have to be carefully "shielded" so that stray electromagnetic fields produced by power sources for the accelerator would not interfere with the operation of the amplifier. They thought that mounting the amplifier on a chassis with a very tight fitting cover would probably provide adequate shielding although they didn't know precisely how tight the cover should be. They gave Pete Demos, a senior mechanical designer working at SLAC, the job of designing the chassis and cover. Not only did the cover have to fit tightly to the chassis, but it also had to be removable so that adjustments could be made in the amplifier from time to time. Pete also was to design the layout of the amplifier parts including racks for circuit cards. He spent about a week on the entire job.

Pete's initial cover design is shown in Figure 2.

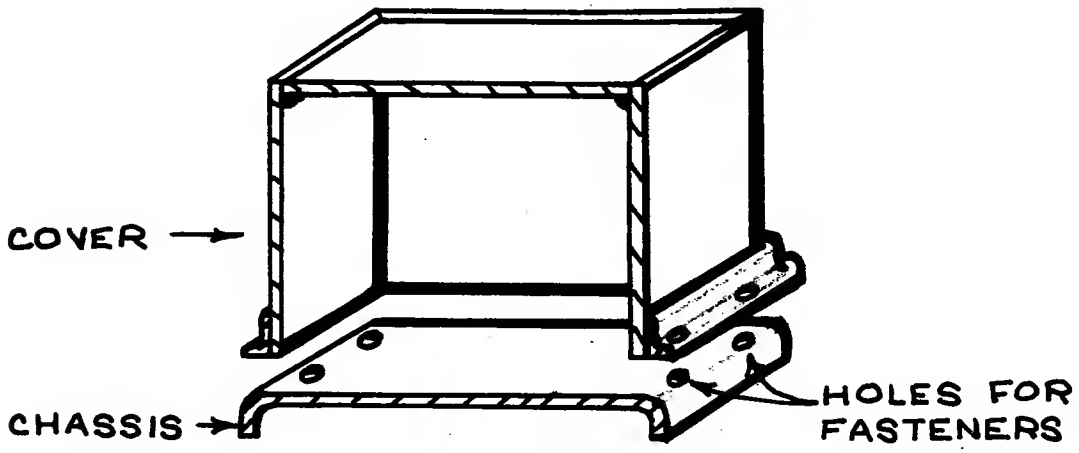


Figure 2

The cover was essentially a rectangular box surrounded by a flange at its lower edges. Since the amplifier had to be shielded, the flange surrounded the cover completely. Sixteen holes in the flange fit over matching holes in the chassis. Sixteen quarter-turn fasteners (see Exhibit I for catalog pages) held the cover to the chassis. Exhibits II and III show Demos' drawings of the chassis and the cover assembly.

Since only one amplifier was to be made, Demos suggested that the machinist simply paste the drawings onto the metal in order to determine the locations of the holes. He also left it up to the machinist to decide how the four parts of the flange should be put together and how the frame should be attached to the cover. Pete specified that the cover should "fit flat with the chassis" and that the flange should be 5/8" by 5/8".

When the machinist began the job, he asked Pete's permission to make a few changes. First of all, there happened to be some 3/4" by 3/4" material on hand in the shop although there was no 5/8" by 5/8" material. The machinist asked Pete if he could use the 3/4" material, and Pete consented. Also, Pete's drawings indicated that the cover should be flat with the flange (Figure 2a) and that the flange should be "vacuum-welded" to the cover. The machinist told Pete that it would be easier to make a vacuum weld if he could weld along a seam on the inside of the cover. He wanted permission to raise the cover slightly above the lower edge of the flange, as shown in Figure 3.

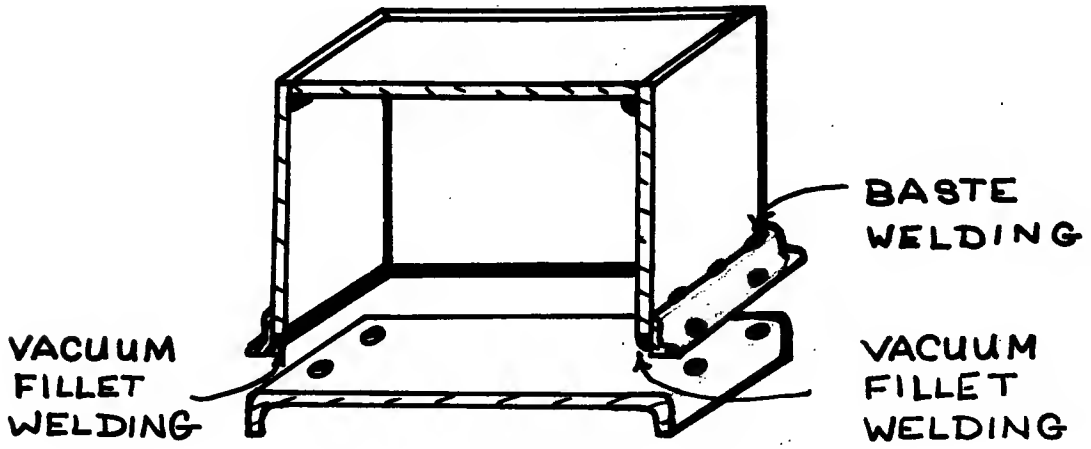


Figure 3

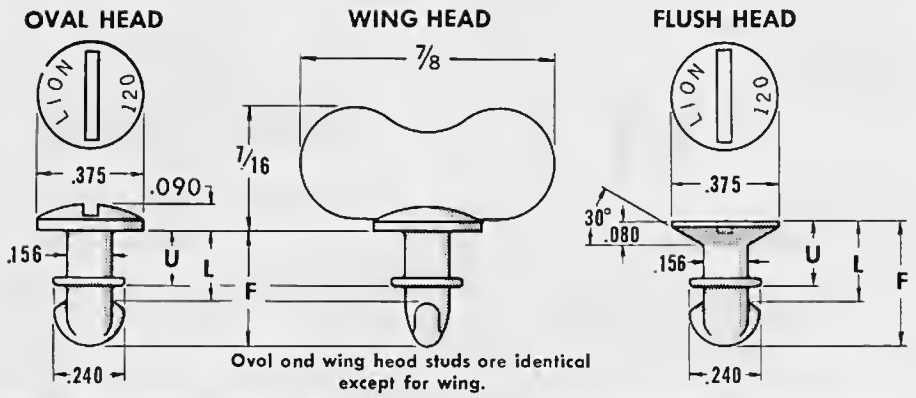
Pete also approved this change. The machinist proceeded to make the flange, which he slipped over the edge of the cover. He fastened the flange to the outside of the cover with several baste welds, shown in Figure 3. Then he turned the cover over and put a fillet vacuum weld all along the "v" which had been produced by raising the cover slightly above the lower edge of the flange. He then placed this assembly on a flat surface and tapped the fillet with a hammer until the lower edge of the cover was as flat as he could make it. After making the chassis, he flattened that in a similar manner.

Next, the instrumentation engineers installed the amplifier on the accelerator pipe. They checked the oscilloscope to see whether the displayed signal was noisy or smooth. Since the signal was smooth, they concluded that the amplifier had been adequately shielded from stray electromagnetic fields.

SOUTHCO LION

No. 2 1/4 TURN FASTENERS

for quick, positive locking of removable sections



Oval and wing head studs are identical except for wing.

All operating characteristics of the No. 2 are similar to those of the No. 5. The one-piece swaged-nose stud without milled sections or cross pins as well as the strong flat receptacle lend unusual strength for a small fastener. Operation is quick and smooth, and little interior space is used by the receptacle.

Studs are formed from one piece for maximum shear strength; case hardened and plated to Mil. spec.

Oval, wing and flush styles are standard. Ring and knurled heads are supplied on special order.

Standard finish is cadmium plate. Bright chrome, satin chrome, nickel or black pentrate on special order. Lettering on stud head may be omitted on special order.

No. 2 STUD SPECIFICATIONS

TOTAL MATERIAL THICKNESS (see page 11)	PART NUMBERS			U	L	F	Weight per M (lbs.)		
	OVAL HEAD	WING HEAD	FLUSH HEAD				OVAL	WING	FLUSH
.070-.089	2-0- 80	2-W- 80	—	.137	.225	.375	3.67	6.50	—
.090-.109	2-0-100	2-W-100	2-F-100	.157	.245	.395	3.78	6.61	3.43
.110-.129	2-0-120	2-W-120	2-F-120	.177	.265	.415	3.89	6.72	3.53
.130-.149	2-0-140	2-W-140	2-F-140	.197	.285	.435	3.99	6.82	3.64
.150-.169	2-0-160	2-W-160	2-F-160	.217	.305	.455	4.10	6.93	3.75
.170-.189	2-0-180	2-W-180	2-F-180	.237	.325	.475	4.21	7.04	3.86
.190-.209	2-0-200	2-W-200	2-F-200	.257	.345	.495	4.32	7.15	3.97
.210-.229	2-0-220	2-W-220	2-F-220	.277	.365	.515	4.43	7.26	4.07
.230-.249	2-0-240	2-W-240	2-F-240	.297	.385	.535	4.54	7.37	4.18
.250-.269	2-0-260	2-W-260	2-F-260	.317	.405	.555	4.65	7.48	4.29
.270-.289	2-0-280	2-W-280	2-F-280	.337	.425	.575	4.76	7.59	4.40
.290-.309	2-0-300	2-W-300	2-F-300	.357	.445	.595	4.87	7.70	4.51
.310-.329	2-0-320	2-W-320	2-F-320	.377	.465	.615	4.98	7.81	4.62
.330-.349	2-0-340	2-W-340	2-F-340	.397	.485	.635	5.09	7.92	4.73
.350-.369	2-0-360	2-W-360	2-F-360	.417	.505	.655	5.20	8.03	4.83
.370-.389	2-0-380	2-W-380	2-F-380	.437	.525	.675	5.31	8.14	4.92
.390-.409	2-0-400	2-W-400	2-F-400	.457	.545	.695	5.42	8.25	5.03
.410-.429	2-0-420	2-W-420	—	.477	.565	.715	5.53	8.36	—
.430-.449	2-0-440	2-W-440	—	.497	.585	.735	5.64	8.47	—
.450-.469	2-0-460	2-W-460	—	.517	.605	.755	5.75	8.58	—
.470-.489	2-0-480	2-W-480	—	.537	.625	.775	5.86	8.69	—
.490-.509	2-0-500	2-W-500	—	.557	.645	.795	5.97	8.80	—
.510-.529	2-0-520	2-W-520	—	.577	.665	.815	6.08	8.91	—
.530-.549	2-0-540	2-W-540	—	.597	.685	.835	6.19	9.02	—
.550-.569	2-0-560	2-W-560	—	.617	.705	.855	6.30	9.13	—
.570-.589	2-0-580	2-W-580	—	.637	.725	.875	6.41	9.24	—
.590-.609	2-0-600	2-W-600	—	.657	.745	.895	6.52	9.35	—
.610-.629	2-0-620	2-W-620	—	.677	.765	.915	6.63	9.46	—
.630-.649	2-0-640	2-W-640	—	.697	.785	.935	6.74	9.57	—
.650-.669	2-0-660	2-W-660	—	.717	.805	.955	6.85	9.68	—
.670-.689	2-0-680	2-W-680	—	.737	.825	.975	6.96	9.79	—
.690-.709	2-0-700	2-W-700	—	.757	.845	.995	7.07	9.90	—
.710-.729	2-0-720	2-W-720	—	.777	.865	1.015	7.18	10.01	—
.730-.749	2-0-740	2-W-740	—	.797	.885	1.035	7.29	10.12	—
.750-.769	2-0-760	2-W-760	—	.817	.905	1.055	7.40	10.23	—
.770-.789	2-0-780	2-W-780	—	.837	.925	1.075	7.51	10.34	—
.790-.809	2-0-800	2-W-800	—	.857	.945	1.095	7.62	10.45	—

Installation Instructions — page 18

MATERIAL and FINISH

Case hardened steel-cadmium plated per Fed. Spec. QQ-P-416 Ty. I, cl. 1.

Stainless steel studs available on special order (except wing head).

WHEN ORDERING, SPECIFY ALL THREE PARTS; STUD, RETAINER, AND RECEPTACLE, BY PART NO.

Oval and flush styles are available with Phillips Recesses (on special order only). Part numbers are 82-19-XXX-16 for oval head, and 82-28-XXX-16 for flush head (XXX is used to indicate grip).

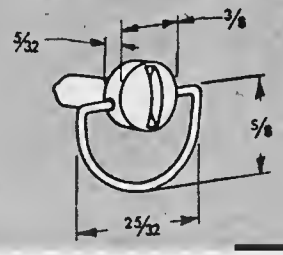
Example: to order oval head stud, part No. 2-0-320 with a Phillips Recess, part number becomes 82-19-320-16.

Part No. in white block = Stock item (subject to prior sale).

Part No. in tinted block = Standard item, mfg. to order.

OTHER HEAD STYLES FOR No. 2 STUDS — SUPPLIED ON SPECIAL ORDER

RING HEAD



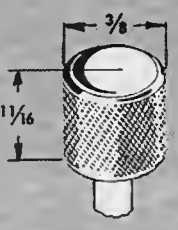
PART 2-K—knurled head studs are supplied with dimensions shown unless other dimensions are specified. Stud dimensions, except head, are same as for oval head stud.

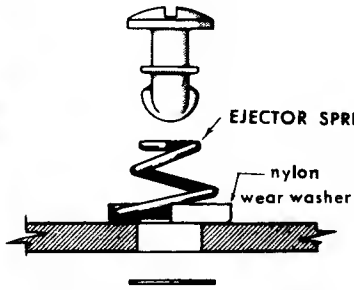
PART 2-RA—for use when spring assembly is horizontal

PART 2-RB—for use when spring assembly is vertical

PART 2-N—Notched head stud also available (not shown—see No. 5 stud, page 13)

KNURLED HEAD



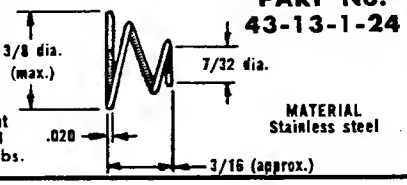


USE SPLIT RING RETAINER ONLY

STUD EJECTOR

To select proper stud length, measure total material thickness, and increase by one grip length (.020) to allow for thickness of spring. If nylon washer is used, increase by one *additional* grip length (.020) to allow for thickness of washer.

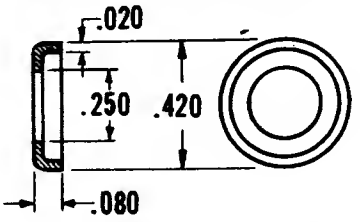
PART No. 43-13-1-24



MATERIAL Stainless steel

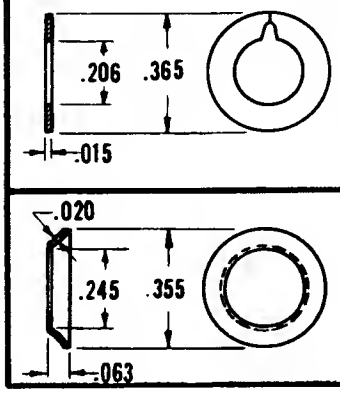
No. 2 NYLON WEAR WASHER

weight per M = .13 lbs.



PART No. { 82-46-101-41—Black
82-46-101-39—Natural

No. 2 RETAINERS



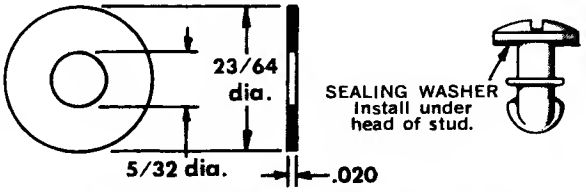
PART NUMBER	MATERIAL AND FINISH	Weight Per M (lbs.)
82-32-101-17 split ring	Spring steel cadmium plated per QQ-P-416 Ty. II, cl. 1	.3
82-32-101-20 split ring	Stainless steel passivated	.3
GO-2-93	Aluminum natural finish	.1
GOS-2-93	Steel cadmium plated per QQ-P-416 Ty. II, cl. 1	.3

STUD SEALING WASHER

PART No. 82-43-201-38

MATERIAL—Neoprene (fabric core) – black.

Weight per M = .078 lbs.



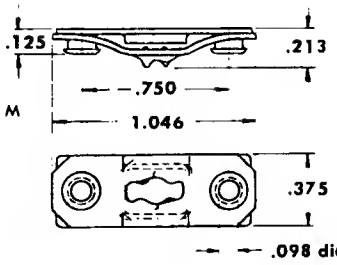
NOTE: To select proper stud length, measure total material thickness and increase by one grip length (.020) to allow for thickness of washer.

NEW . . . LEAF SPRING RECEPTACLE, TYPE B (RIVET and WELD types)

Full floating leaf type receptacle with base, similar in basic design to No. 5 size, offers maximum strength. Minimum envelope dimensions afford savings in space and weight.

RIVET TYPE

PART No. 82-35-302-15



Weight per M 6.19 lbs.

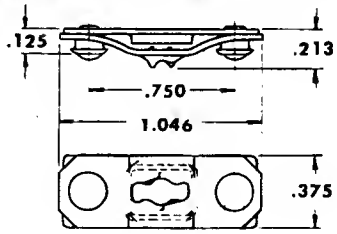
MATERIAL & FINISH

Spring — spring steel. Base — steel. Entire receptacle is cadmium plated per QQ-P-416 Ty. II cl. 1.

WELD TYPE

PART No. 82-35-303-15

(welding studs are supplied in assembly)



Weight per M 6.35 lbs.

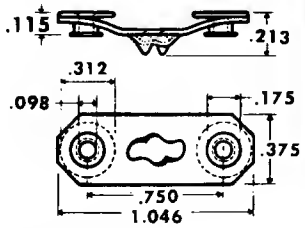
Installation instructions — page 18

LEAF SPRING RECEPTACLE

Same operating characteristics as No. 2 receptacle shown above, but offered *without* base for use where additional saving in weight is desirable.

PART No. 2-295

MATERIAL and FINISH: Spring steel, cadmium plated per QQ-P-416 Ty. II, cl. 1.



Weight: 3¾ lbs. per thousand.

Installation instructions — page 18

No. 2 SIDE MOUNT RECEPTACLE

To select stud length, measure distance from outer surface of panel to top surface of side mount. Add constant of .062 and enter stud table (page 16) with this dimension.

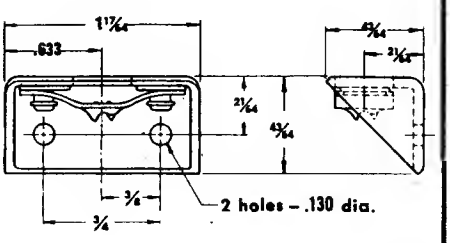
PART No. 82-45-101-15

MATERIAL AND FINISH:

Bracket—steel—cadmium plated per QQ-P-416, Ty. II, cl. 1

RECEPTACLE—Same as PART No. 2-295

WEIGHT— .03 lbs. per assembly



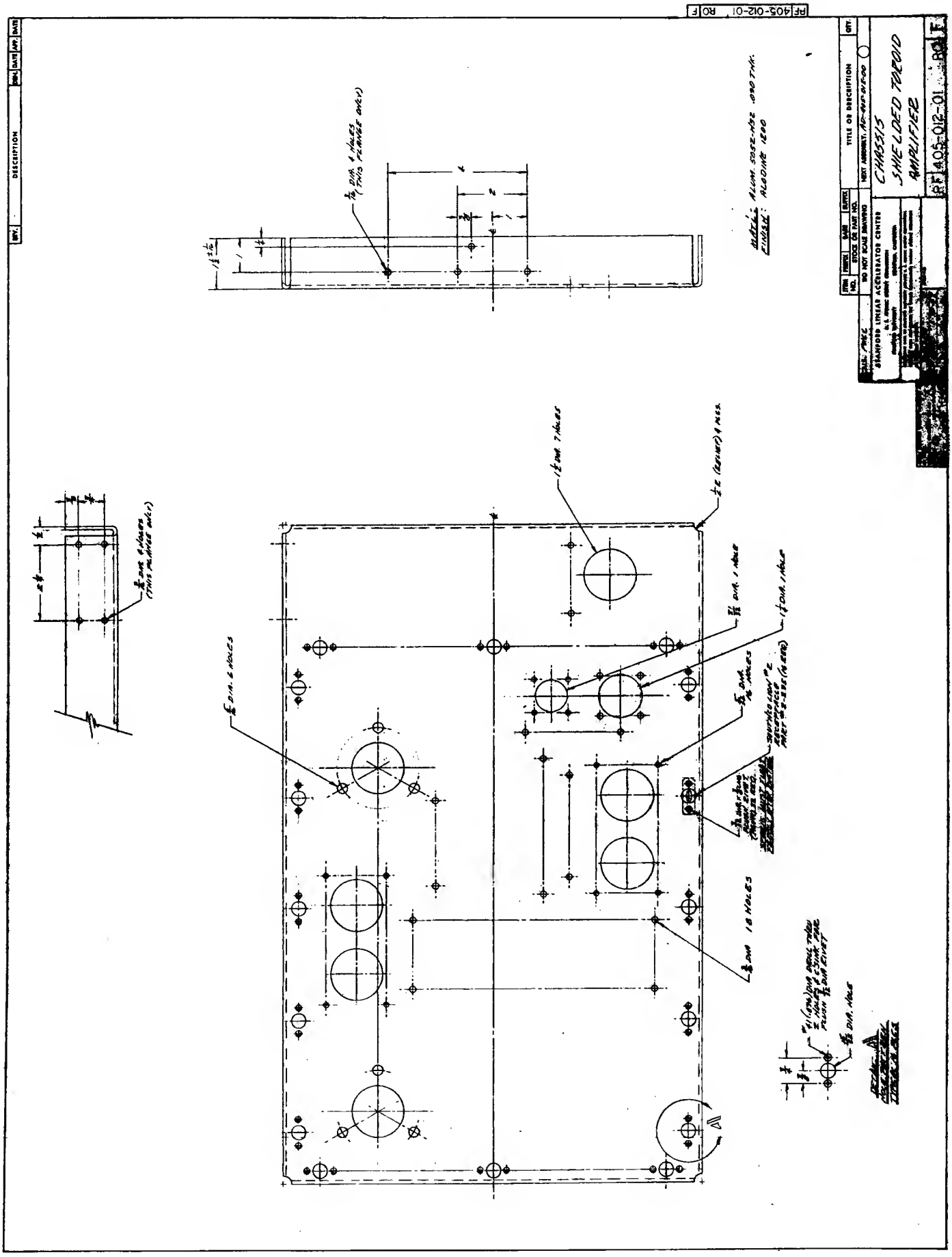

CHASSIS
SHIELDED TOROID
AMPLIFIER
RF 405-012-01
STANFORD LINEAR ACCELERATION CENTER

Exhibit II

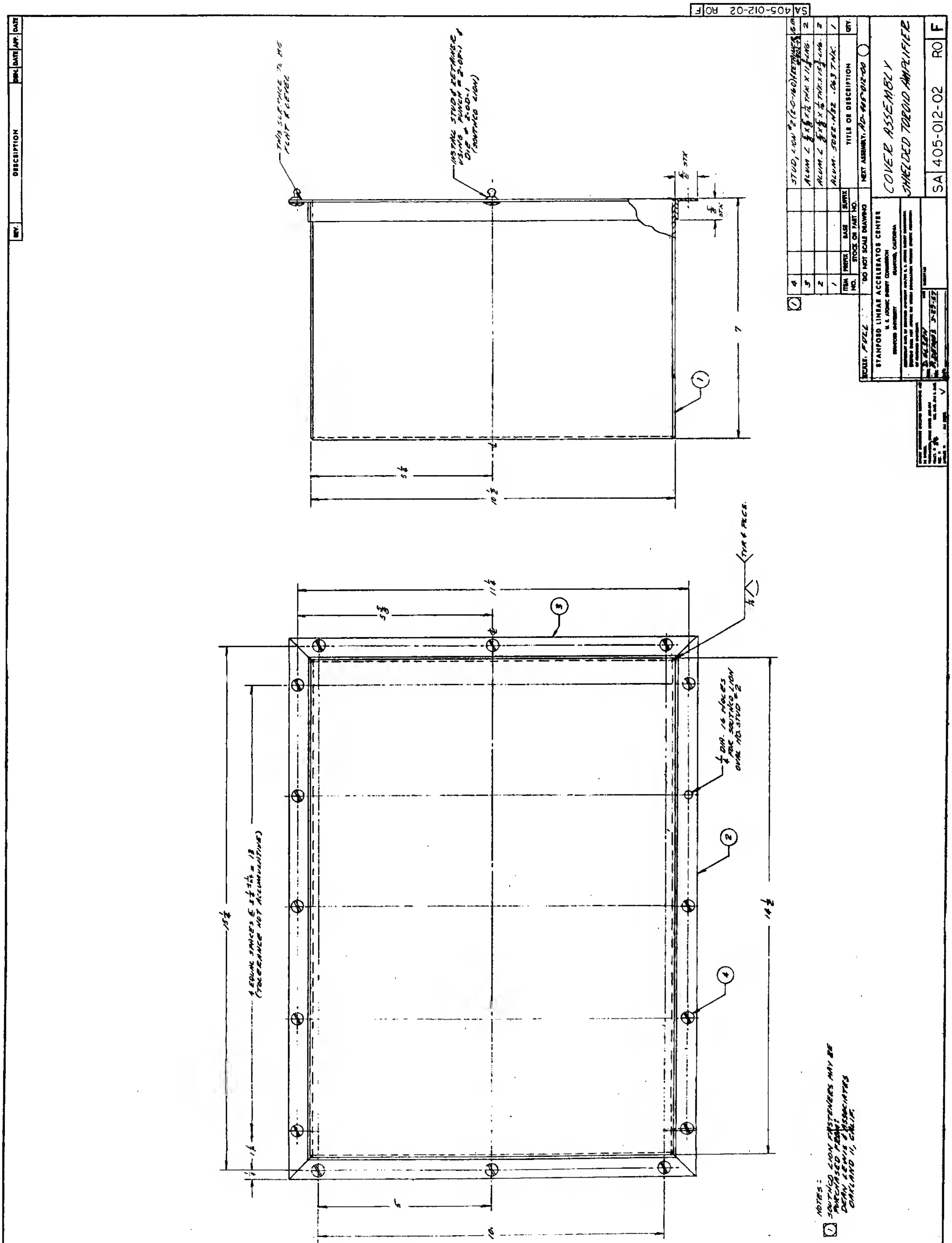

SA 405-012-02 R0 F
COVER ASSEMBLY
SHIELDED TOROID AMPLIFIER
STANFORD LINEAR ACCELERATOR CENTER
DO NOT SCALE DRAWING
TITLE OR DESCRIPTION
NOTES:

Exhibit III